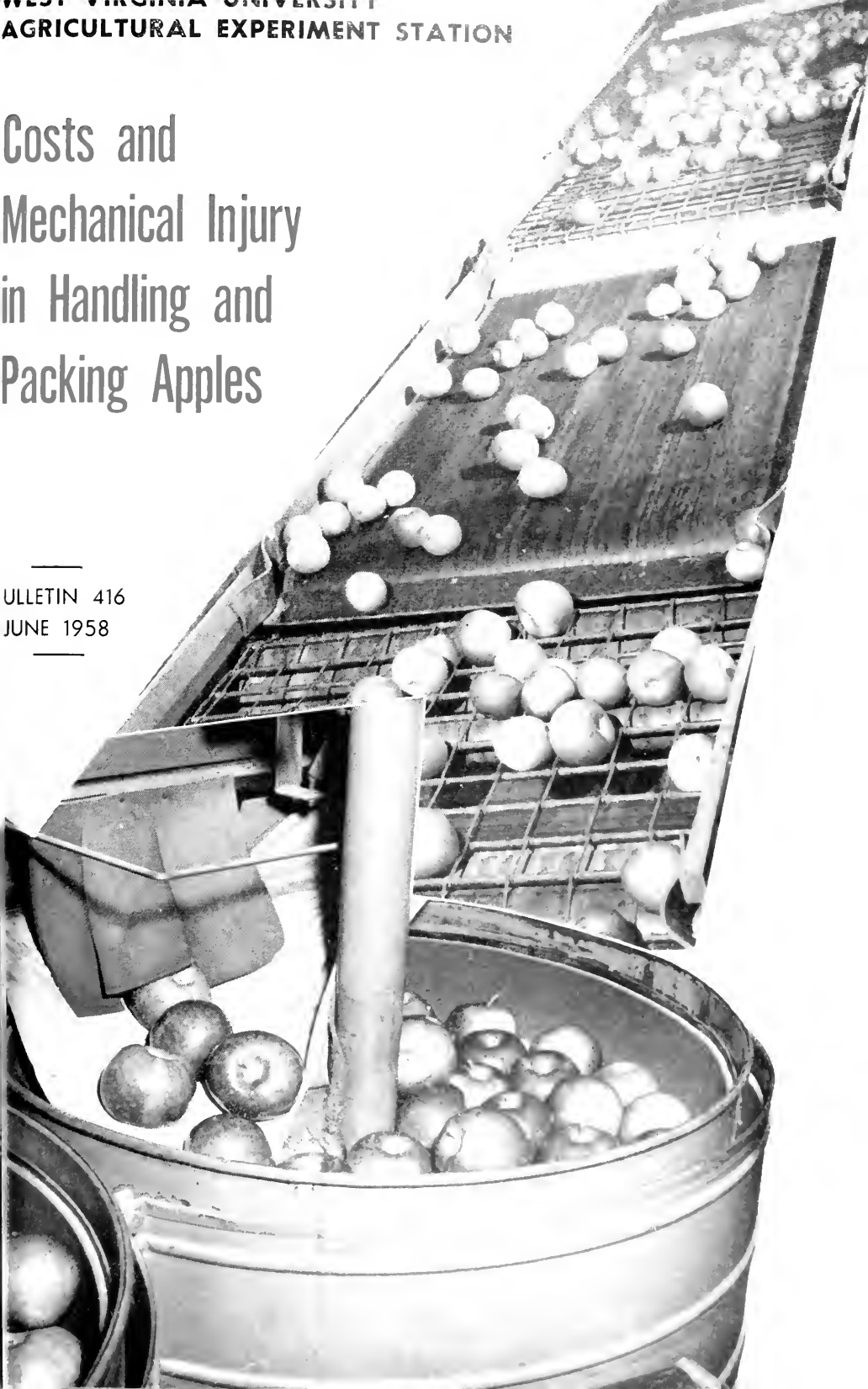
WEST VIRGINIA UNIVERSITY
AGRICULTURAL EXPERIMENT STATION

Costs and Mechanical Injury in Handling and Packing Apples

ULLETIN 416
JUNE 1958



THE AUTHORS

Authors of *Cost and Mechanical Injury in Handling and Packing Apples* are Homer C. Evans and Ray S. Marsh. Homer C. Evans is Associate Agricultural Economist in the Agricultural Experiment Station, and Ray S. Marsh is Professor and Head of Horticulture in the College of Agriculture, Forestry, and Home Economics, and Horticulturist in the Agricultural Experiment Station.

West Virginia University
Agricultural Experiment Station
College of Agriculture, Forestry, and Home Economics
A. H. VanLandingham, Acting Director
Morgantown

Preface

THIS is the first of a series of reports covering work done on handling methods and on costs of packing apples in the Appalachian Area. The over-all project has the following objectives: to discover ways of reducing costs of handling, packing, and storing apples under conditions prevailing in the Appalachian Area, and to determine the extent of mechanical injury to apples caused by different equipment and methods. However, this particular report deals only with the costs of packing and handling apples, and the degree of mechanical injury for the 1956 and 1957 seasons. An evaluation of the relative efficiency of different machines and work methods will be made in another report, using time and motion and work-sampling data.

This study was carried out jointly by West Virginia University and the Agricultural Marketing Service (AMS), United States Department of Agriculture (USDA). It is a part of Northeast Regional Project NEM-19, "Handling Methods and Costs in Storing and Packing Apples."

Acknowledgement

The authors appreciate the cooperation of the apple growers and packers in the Appalachian Area. They were most helpful in making data available and in permitting the researchers to study their operations.

The following personnel from the Agricultural Marketing Service, United States Department of Agriculture have contributed much to this study: Robert Bogardus, Stanley W. Burt, William H. Elliott, Joseph H. Herrick, Jr., Alden C. Manchester, Loyd C. Martin, and Jules V. Powell. They helped in the planning of the project, the collection of data, and have given helpful suggestions in the preparation of this manuscript.

The pictures were taken by David Creel of the West Virginia University Agricultural Experiment Station and USDA personnel.

Costs and Mechanical Injury in Handling and Packing Apples

Introduction

THIS report is concerned with the costs of packing and handling apples, and with the extent of mechanical injury to apples in a selected group of packing houses which use the various equipment and work methods found in the Appalachian Area in 1956-57. No attempt is made to explain variations in costs among plants because there were differences which are not accounted for in this report. These differences include the wide variation in management and supervision, and the wide variation of work time and idle time among plants and among jobs within a plant. The effects of these variables will be discussed in another report.

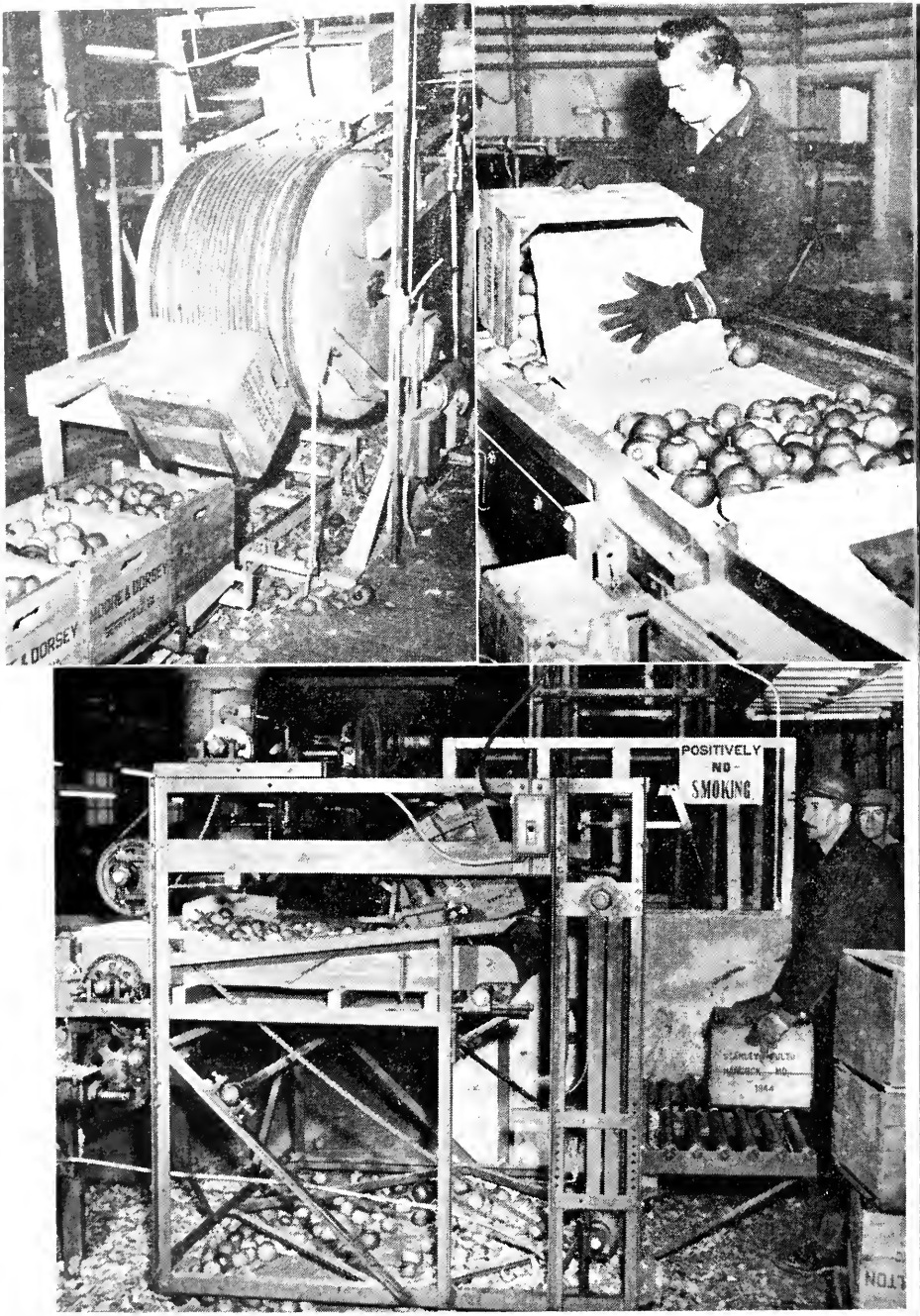
Selection of Packing Houses Studied

A preliminary survey was made of the larger packing houses in the Appalachian Area between Winchester, Virginia, and Mercersburg, Pennsylvania, to determine the different types of equipment and the work methods being used in the larger packing houses. The packing of 50,000 bushels per season was set as the approximate lower limit of the packing houses to be surveyed. Schedules were taken on the operations of 36 packing houses: 17 in West Virginia, 8 in Virginia, 4 in Maryland, and in Pennsylvania. From these, 8 were selected for detailed study. They had all the different types of equipment and work methods found in the 36 plants originally surveyed. A diversity of equipment and work methods was needed to give a picture of costs and injury under present conditions—pictures 1 and 2. In the next phase of this study, this diversity will serve as the basis for determining the most efficient of the present methods of handling and packing apples.

Part I: PACKING AND HANDLING COSTS

Procedure

ALL packing-house labor costs were figured per "packed container." The net weight of packed containers varied, depending on the variety of apple and the type of container; however, each container held



PICTURE 1—Three methods of dumping apples.

PICTURE 2—Three methods of tray packing.

approximately one bushel. The following were counted as packed containers: tray pack, Northwest box, bushel basket, fifteen three-pound bags, twelve four-pound bags, and nine five-pound bags. In cases where sized and graded apples were stored temporarily in bulk, the field crate was counted as a packed container for purposes of figuring per-unit dumping, grading, and overhead costs.

In determining labor costs, the time required for performing each of the various packing-house jobs was recorded. In each case, time requirements were based on total man-minutes of the workers engaged in the jobs under observation. Unit-time-requirements were obtained by dividing total man-minutes by the number of packed containers produced during the time periods observed. Labor costs were obtained by multiplying the unit-time-requirements for the various jobs by the wage rate paid for each job. Data were taken in each packing house for approximately one week.

Overhead and material costs were obtained from the owners and managers of the packing houses studied. The costs were taken either from accounting records of the firms or from the owners' estimates in cases where records were not kept in the detail needed. In most cases estimates were obtained for repairs, heat, power, telephone, insurance and taxes because costs for these services had to be allocated between packing operations and other operations, such as storage and general orchard operations. Buildings were depreciated at a rate of 3⅓ per cent per year, and equipment was depreciated at the rate of 10 per cent per year. No charges were made for interest on investment. Per-unit overhead costs were obtained by dividing total overhead costs for the year by the number of bushels packed in the packing house for the season.

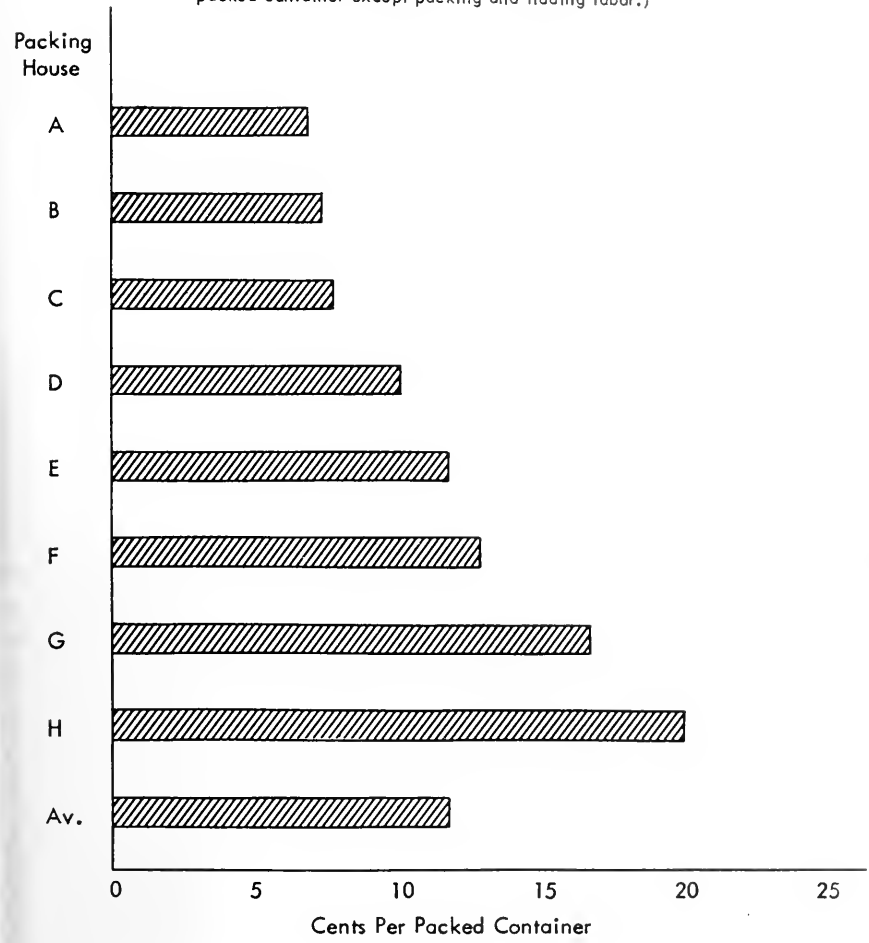
Packing Costs

LABOR COSTS

Packing labor costs start with the apples in temporary storage near the dumping operation and include all labor involved through the stacking of the packed containers. Labor requirements for certain jobs are independent of the type of container used while packing (or filling the container), and lidding labor is related to the type of container. The following operations must be performed in about the same manner, regardless of the type of container used: dumping, grading, packing the table culls, stamping, weighing, tallying, stacking empty boxes, stacking packed containers, supervising, and miscellaneous. Packing-house labor costs are divided into two groups: "general labor," which includes labor for the above listed jobs, and "packing and lidding labor." Figure shows packing-house general-labor costs. The range in costs among plant

Figure 1. Packing House General Labor Costs Per Packed Container in Eight Packing Houses, Appalachian Area, 1956.

(General packing house labor includes all packing house labor involved in packing apples from dumping through stacking the packed container except packing and lidding labor.)



was from a low of 6.9 cents per packed container to a high of 20.0 cents, with an average of 11.7 cents. Table 1 shows a detailed breakdown, by jobs, for packing-house general labor.

By design, plants were selected which had to have the different types of machines and work methods used in 1956 by the larger Appalachian plants; consequently, there was a wide range in costs among plants.

TABLE 1. PACKING-HOUSE-GENERAL-LABOR COSTS PER PACKED CONTAINER IN EIGHT PACKING HOUSES, APPALACHIAN AREA 1956

OPERATION	PACKING HOUSE							
	D	H	G	E	B	A	C	F
				(*Cents Per Container*)				
Dumping	0.6	1.5	1.1	1.6	0.5	0.8	0.4	0.9
Grading	2.9	9.0	8.9	7.2	2.1	2.9	2.5	5.8
Packing Table Culls	0.6	2.3	0.9	0.9	0.7	0.4	0.4	1.3
Stamping, Weighing and Tallying	0.6	1.9	1.5	0.6	*	*	0.7	0.8
Stacking Empty Boxes	0.4	0.3	0.2	0.3	0.3	0.3	0.5	0.4
Stacking Packed Containers	0.7	1.8	0.9	**	1.6	0.9	1.4	0.9
Supervising	2.6	1.8	1.5	0.6	1.6	1.2	0.8	1.5
Miscellaneous	1.7	1.4	1.7	0.5	0.6	0.4	0.9	1.2
TOTAL	10.1	20.0	16.7	11.7	7.4	6.9	7.7	12.8

*Stamping, weighing and tallying not done by two packers.
**No data taken.

Figure 2 shows labor costs for packing and lidding, by plants, for the tray pack, Northwest box, and bushel basket. In cases where packers were paid on a piece-rate basis, that rate was used rather than labor requirements in man-minutes multiplied by wage rate. The tray pack was the most widely-used type of container. Packing-and-lidding costs for the tray pack ranged from a low of 3.2 cents per container to a high of 13.5 cents, and averaged 8.9 cents. All eight packing houses studied used the tray pack.

Four of the eight used the Northwest box, with a range in packing-and-lidding labor costs from a low of 10.9 cents per container to a high of 18.1 cents, and with an average of 13.6 cents.

Three packing houses used the bushel basket. Packing-and-lidding labor costs ranged from a low of 7.6 cents to a high of 18.6 cents, with an average of 12.1 cents per packed basket.

OVERHEAD COSTS

Overhead costs were computed on a per-packed-container basis rather than on the number of bushels dumped. This was based on the assumption that a packing house is not needed for selling apples to the processor; consequently, all packing-house costs should be charged to packed apples. Picture 3 shows typical packing-house equipment. Overhead costs ranged from a low of 5.7 to a high of 18.7 cents per packed container, with an average of 10.0 cents—Figure 3.

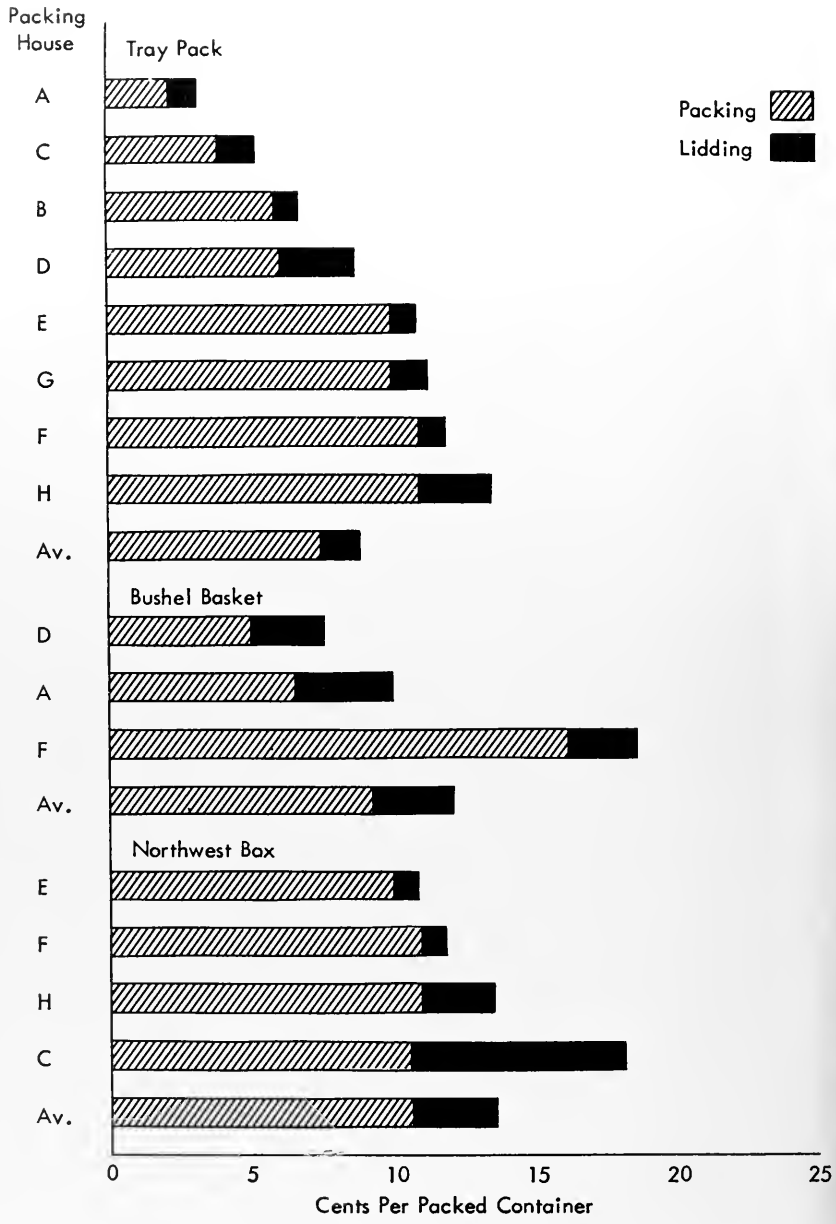
CONTAINER COSTS

Container costs account for a major part of total packing-house costs. Table 2 shows the average, high, and low costs for the tray pack, the basket, and the Northwest box containers, complete at the packing line. Among plants, there was little variation in costs for the same type and quality of container. However, there was considerable variation in the cost of a particular type of container, depending upon its materials, construction, and finish. This was particularly true for the tray pack, depending on whether or not it was suitable for storage. Therefore, the variation in cost for a particular type of container, as shown in Table 2, was due to variation in the quality of the container and not to variation among plants for the same quality of a particular container.

TOTAL COSTS

Average total costs for packing apples in 1956 in the eight plants studied were 86.2 cents for the bushel basket, 90.7 cents for the tray pack, and 103.7 cents for the Northwest box, Figure 4. The container, complete at the packing line, was the largest single cost item in packing apples for the fresh market. The container, on the average, represented approximately two-thirds of total packing costs. Labor was the next-largest packing-cost item, and overhead cost was least.

Figure 2. Packing-and-Lidding Labor Costs, in Eight Packing Houses, Appalachian Area, 1956.



PICTURE 3—Typical packing-house equipment.

Handling Costs

With the adoption of the use of the industrial fork-lift truck, some apple growers have changed considerably their methods of handling apples and possibly their costs of doing the job—Picture 4. In 1957, a study was made of the costs of handling apples, including both receiving and loading-out operations.

RECEIVING COSTS

Figure 5 shows the handling costs of three growers for moving one-hundred crates of apples from under the tree to the packing house. These costs included only the costs involved in loading and unloading the apples and did not include the costs of the truck and driver from

Figure 3. Overhead Costs Per Packed Container, in Eight Packing Houses, Appalachian Area, 1956.

(Other overhead includes repairs, light, heat, power, telephone, insurance and taxes.)

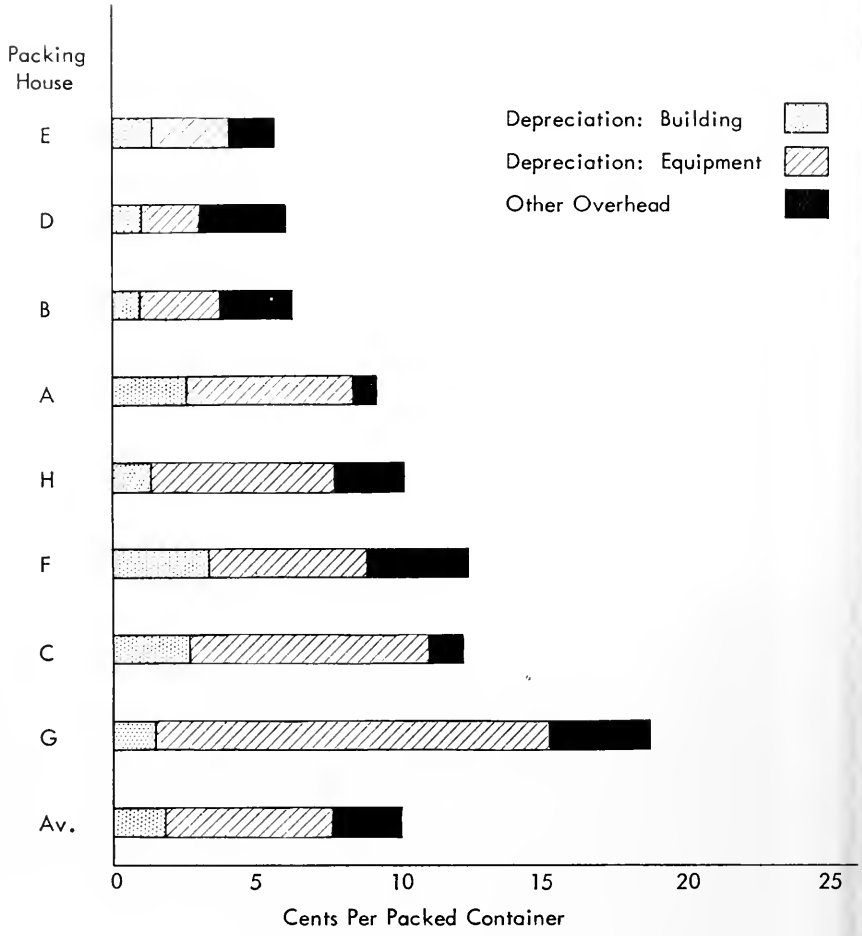
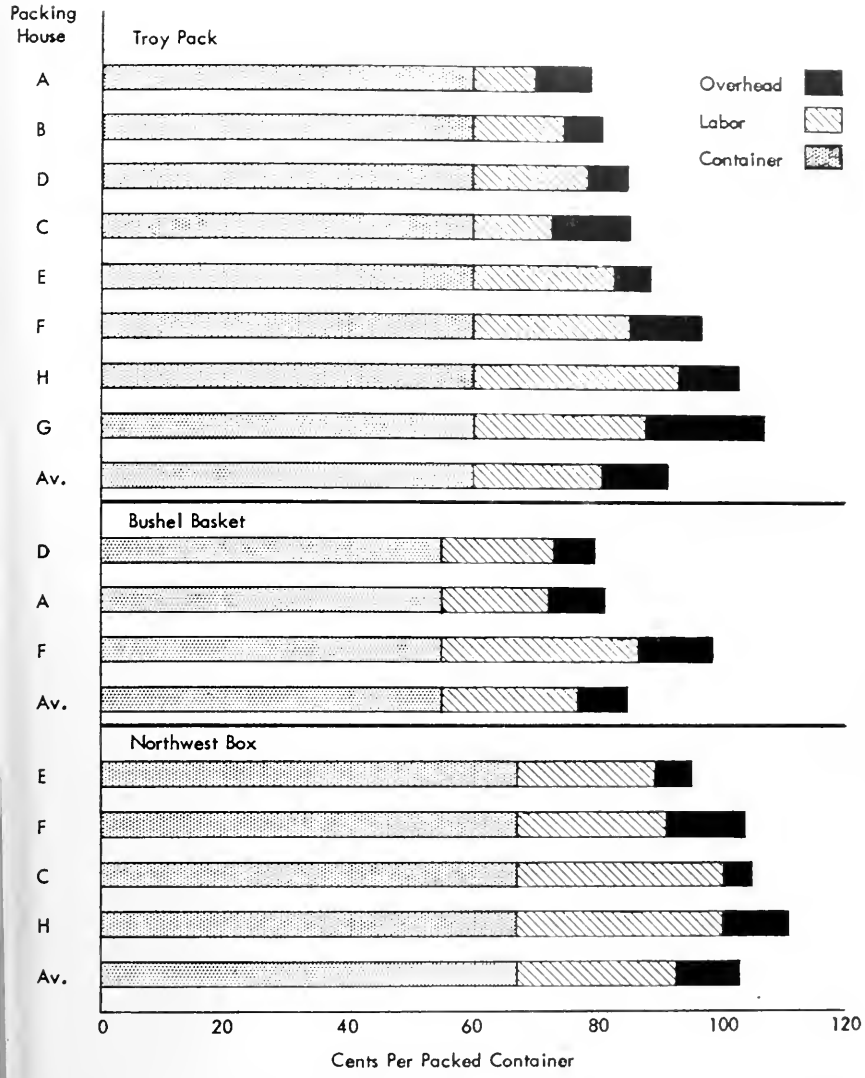


TABLE 2. CONTAINER COSTS BY TYPE OF CONTAINER (COMPLETE AND AT THE PACKING STATION) IN EIGHT PACKING HOUSES, APPALACHIAN AREA 1956

TYPE OF CONTAINER	COST PER CONTAINER		
	LOW	HIGH	AVERAGE
		(*Cents*)	
Tray Pack	45	70	60
Basket	54	55	55
Northwest Box	62	73	67

Figure 4. Total Packing Costs by Type of Container, in Eight Packing Houses, Appalachian Area, 1956.



he orchard to the packing house. Travel time varied with the distance raveled, and loading and unloading methods should have little effect n it. However, loading and unloading time does affect the total productivity of the truck and driver, depending on the time required to oad and unload.

Handling costs for moving one hundred crates from under the tree o the packing house were $0.69 for grower A, $1.10 for B, and $2.53

PICTURE 4—A fork-lift truck.

for C. A constant rate of $1.63 per hour was charged to all growers for the use of a fork-lift truck.[1] Actual wage rates or piece rates paid by the growers studied, were used. In the case of grower C, a piece rate of 2 cents per crate for loading in the orchard was paid. This made costs of that method relatively high.

LOADING-OUT COSTS

Figure 6 shows the handling costs for loading out one hundred packed containers at seven different packing houses. Actual wage rates paid by the different operators were applied, and $1.63 per hour was charged for all fork-lift truck time. The range in costs was from a low of $0.47 to a high of $0.83.

[1]This rate was taken from "Apple Handling Methods and Equipment in Pacific Northwest Packing and Storage Houses." Market Research Report No. 49, PMA, USDA, 1953. This report also gives the method used in arriving at a rate of $1.63 per hour.

Figure 5. Selected Handling Costs from Tree to Packing House, Appalachian Area, 1957.

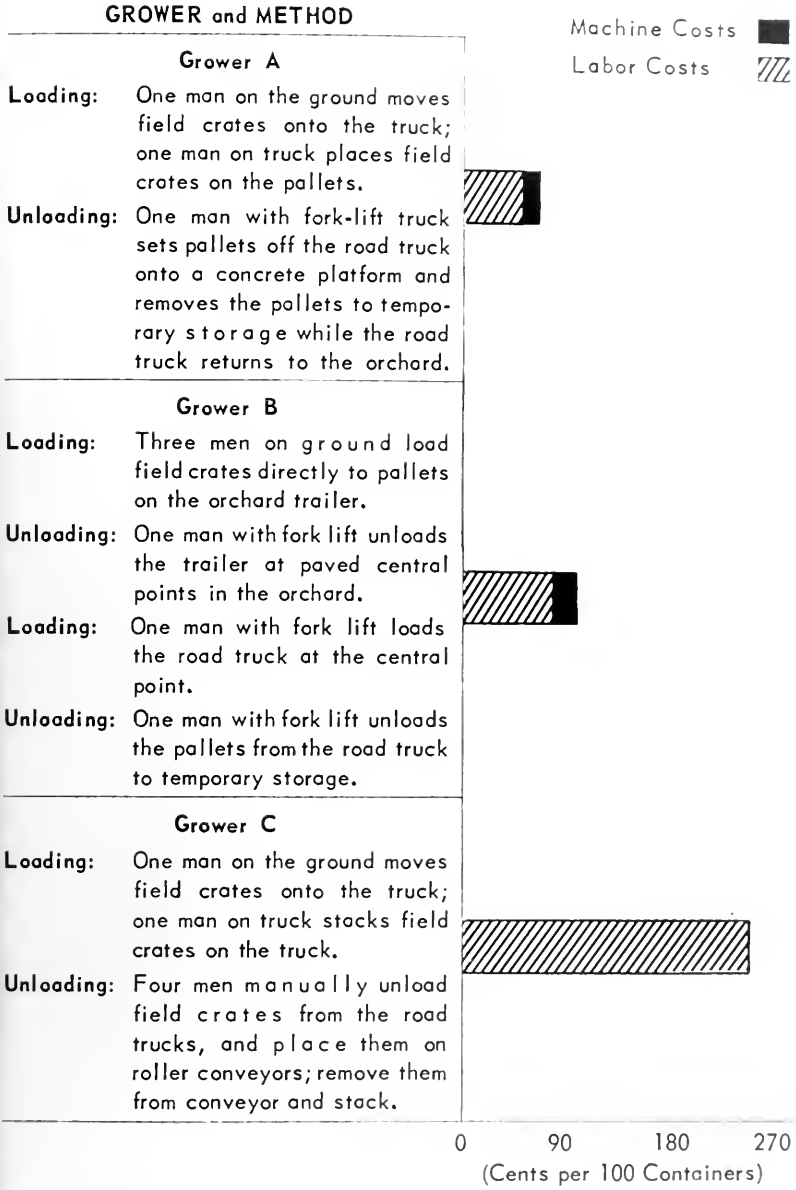
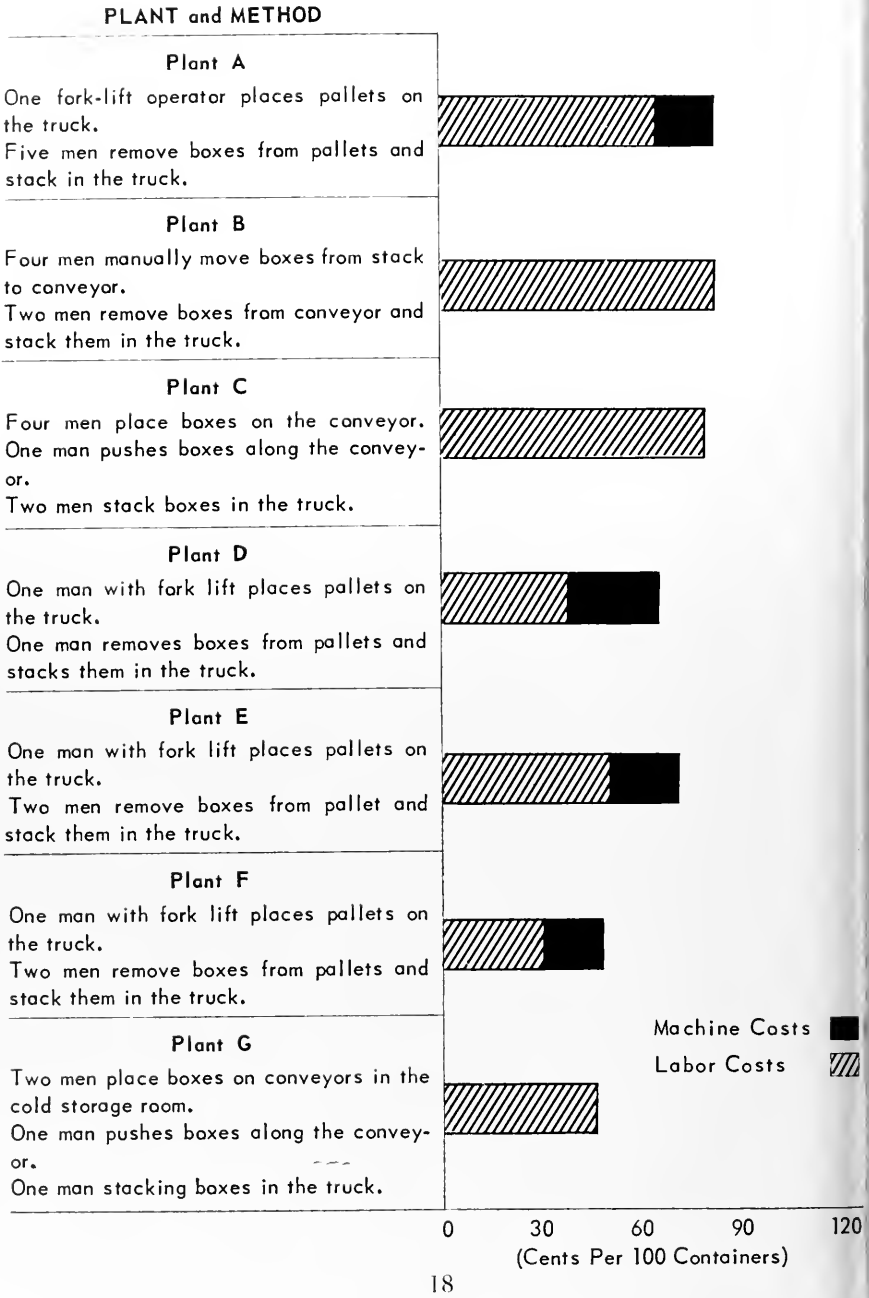


Figure 6. Handling Costs for Loading-Out Packed Apples, Appalachian Area, 1957.



Part II: MECHANICAL INJURY OBSERVATIONS

IT is not feasible to provide consumers with apples completely free of mechanical injury. Under present conditions, in a large volume enterprise, to give the consumer a bruise-free fruit would require a complete and careful hand operation, because no machine now used in packing apples can be as gentle as the manual method. Each apple would be picked individually, placed in a cell carton at the orchard, and carefully moved through storages and warehouses to the retailer's display counter. To do this in a large fresh-fruit-packing operation would involve labor costs which would preclude any net returns. Therefore, good management is constantly seeking methods and machinery to reduce labor costs. Since the consumer is tolerant of a few minor bruises on apples, there is no reason at present to place on the market fruit that is completely free of mechanical injury. Consequently, when a new piece of machinery is developed, it should be tested for any damage it will do to the fruit. If tests show only a minor amount of bruising it may be practical to use it since consumers will tolerate some bruises on apples.

Procedure

In the eight packing houses under study, several methods and machines were tested for mechanical damage. In 1956, bruise-free fruits were used in lots of 100 apples and were run through a given operation or unit of machinery and then examined for bruise injury. Randomized sampling was done in 1957, and bruising was recorded at certain breakdown spots from the time the apples arrived at the packing house until they left in the final packages.

This guide was used for determining the extent of mechanical injury: if on any one apple the sum of the bruised areas was one-half to three-fourths of an inch, the apple was recorded as slightly bruised. If the bruised areas totaled three-fourths to one inch, the apple was recorded as moderately bruised; if one inch or over, the apple was recorded severely bruised.

The following break points in packing-house operations were chosen for observing mechanical damage to the apple: (1) The fruit in field crates as it arrived on the floor of the packing house from the orchard or storage. (2) Dumping the apples on the receiving belts. (3) The movements of fruit over the elevators and sorting rolls. (4) The passing of the apples through sizing mechanisms. (5) Packaging fruit from the trace-off areas.

The field-crate de-stacker and automatic-field-crate-filling device were not tested for their damage to fruit. It is probable that the two machines produce less bruising to apples than the average manual operation for these two jobs. The two packing houses with the automatic-crate fillers used them exclusively for handling culls and off-grade fruit.

Injury on Arrival at Packing House

The first analysis of injury was made when the apples arrived in field crates at the packing-house floor for cleaning, sorting, sizing, and packaging. As shown in Table 3, the range of bruise-free fruit was from 34 to 98 per cent. The two orchardists who had the least and the most bruised fruit as it arrived at the packing house both used pallets. Everything else being equal, the use of pallets should reduce mechanical injury to the fruit. Two growers handling apples in individual-field crates without pallets had 60 and 80 per cent of bruise-free fruit. There is an indication that quality was maintained in transporting the palletized fruit from the orchard to the packing house.

Mechanical Dumping Versus Hand Dumping

The greatest variation in the amount of bruising was found in apples dumped on the receiving belt by hand or manual methods. One operator was able to place the fruit on the receiving belt without causing any additional bruising. Another operator added from 27 to 50 per cent bruising by hand dumping. There was less variation in bruising when dumping was done by mechanical means. In four packing houses where a drum dumper was used, from 2 to 8 per cent of the fruit was bruised. One straight-line dumper added 6 per cent bruising. From these results, it would seem that mechanical dumping could be used in some operations to reduce the wide variation found in the hand or manual methods—Picture 1.

After the apples are dumped on the receiving belts they travel through a brushing or cleaning machine. These machines are very much alike and added up to 10 per cent mechanical damage to the fruit. One packing-house operator removed the top unit of brushes or polishing cloths from the cleaner and replaced it with a medium-weight floor rug which eliminated more than one-half of the mechanical damage usually caused by brushing the fruit.

Injury from Elevator Chains and Sorting Rolls

Elevators and sorting rolls were very similar in all plants surveyed except in two cases. In one packing house, the ordinary or usual wooden

Table 3. The Extent of Mechanical Injury Found on Apples in Eight Packing Houses in the Appalachian Area, 1957*

Packing House	Variety	Pressure Test	Points at Which Bruise Counts Were Made						
			At Dumping Station**		Type Container	At End of Packing Line†			
						Degree of Bruising			
			Bruised (All Types)	No Bruise		None	Slight	Moderate	Severe
		(Pounds)	(Per Cent)			(Per Cent)			
1	Red Delicious	20	49	51	Bags	49	13	7	1
2	Red Delicious	18	36	64	Bags	64	33	2	1
3	Red Delicious	18.5	20	80	Bags and Tray Pack Cartons	66	29	5	0
4	Stayman	19	56	44	Tray Pack Cartons	32	54	14	0
5	Stayman	15	66	34	Bags	34	49	16	1
6‡	Red Delicious	18	40	60	N. W. Boxes and Bags	71	28	1	0
7	Golden Delicious	18	34	66	Tray Pack Cartons	42	46	9	3
8***	Rome	14	2	98	Tray Pack Cartons	94	6	0	0

*Data presented in the narrative are not additive for the different units so as to give a total that will check with the data presented in this table.

**The apples were received at the dumping station either directly from the orchard or from cold storage and were in field crate

†Samples were taken from packed containers after the containers had been closed.

‡The percentage of fruit bruised was reduced in the packing operation by culling out more bruised apples than were damaged in the process.

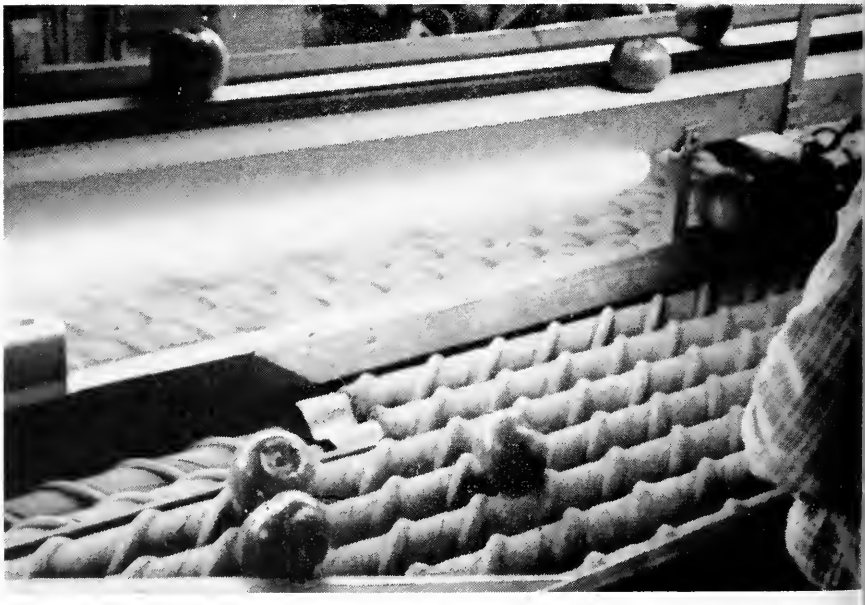
***Management was more important than ripeness (as measured by pressure test) in determining the extent of mechanical injury

rolls were covered with felt to reduce bruising—Picture 5. This was an improvement, and with the slow speed of machinery in this particular operation, there was no damage to the fruit as it passed up the elevator and over the sorting rolls. In another packing house where a float-roll sorting table was used, bruising was 2.6 per cent. The other six packing houses showed bruising from elevators and sorting rolls of from 1 to 10 per cent. Some of this variation can be accounted for by the speed of operation and height of the drop from elevators to sorting rolls. Also, sorting for color and blemishes, as separate operations, subjected the apples to additional time and hazard on the machines. With slower speeds, with less drop from elevator rolls or chains, with the use of cloth brakes over apples coming down inclines and with felt covering on the ordinary wooden rolls, it is possible to eliminate bruising on this area of packing-house machinery.

Sizing Machine Damage

The Cutler or weight-type sizer was used in six of the eight packing houses surveyed. In one house, a rapid sizer was used—Picture 6. In two packing houses, the chain-sizing method was used.

The Cutler or weight-type sizing machine was found to cause from 2 to 6 per cent bruise damage, with an average of 4 per cent. The source of injury in one case was due to the singulator wheel being out of ad-



PICTURE 5—Felt-cover-sorting rolls.

PICTURE 6—Sizer unit (dimensional-type sizer based on principle of gradually expanding plastic cups).

justment. With this type of machine, most of the damage was done by apples dropping from the cup and hitting each other in the tub. In one house, a longer-than-standard canvas apron was used, with a pad of felt on the underside to help brake the fall of the apples from cup to tub. This felt underpad seemed to add polish to the apples as the tub revolved. Along with this improvement, a one-half-inch-thick sheet of sponge rubber was used, measuring 8 x 10 inches, with 3 fingers cut into it. These fingers acted as a brake on the top side of the apples when they dropped from the cups to the tubs—Picture 7.

The chain sizers, when properly used, averaged 6 per cent mechanical damage. Here again, the drop through the chain to a moving belt below bruised the apples when they came in contact with each other. Frequently an apple was bruised and its skin broken when it became wedged between the chain and a roller.

The rapid-sizer or plastic-cup dimension-type machine averaged 3.5 per cent bruising—most of which occurred when the fruit dropped from the cups to a moving belt for delivery to the take-off bins. This machine has a large capacity for the floor space it occupies.

Packaging Damage from the Take-Off Areas

Tray-pack boxes, consumer-size bags, and the Northwest box were the package types used. For filling trays and boxes, hand placing and packing was practiced in all packing houses. All houses used some type of bagging machine on consumer-unit packing. One house used the automatic tray-filling unit for packing tray pack. The bruise-free fruit varied from 32 to 94 per cent in the final package, as observed in the eight plants—Table 3.

PICTURE 7—Illustration of how management improves standard equipment to prevent mechanical injury.

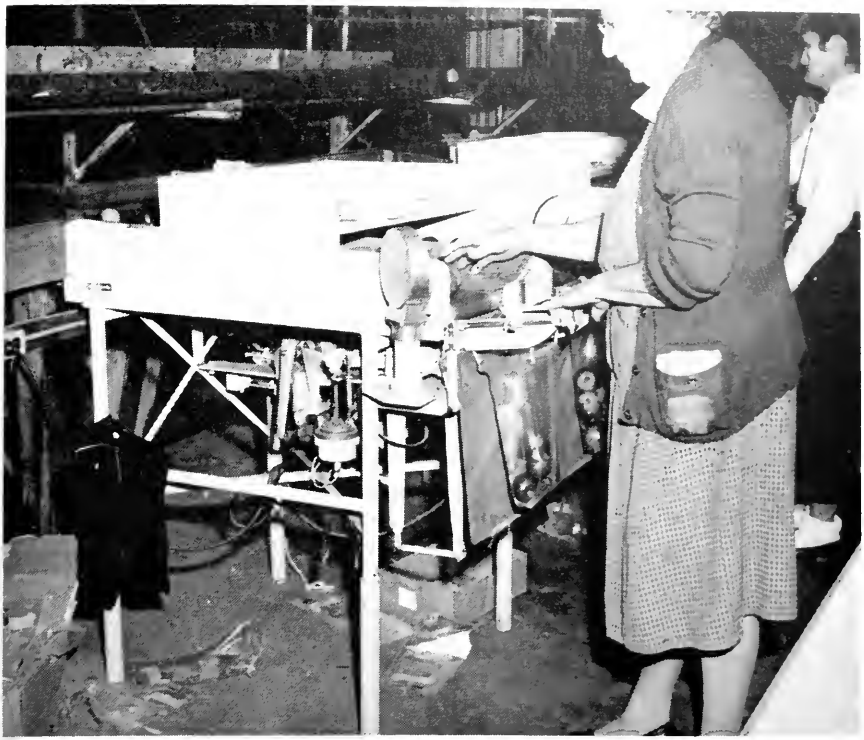
It was found that where bagging machines were properly used, there was no bruising; however, when apples were run from the machine in a straight downward drop to the four-pound polyethylene bag, there was 9 per cent bruising—Picture 8. When the fruit was allowed to run on a sloping drop into the bag, no bruise damage resulted.

It was found that the automatic tray-filler machine averaged 11 per cent bruising, but this may be due to manually forcing a filled tray to the bottom of the tray box. Again, if this machine were properly operated and if the tray were allowed to settle by its own weight against a partial-air cushion, mechanical damage would be reduced.

The hand placing of fruit into tray and box packs caused no damage.

Summary

The most significant findings of this study are: the wide variation in packing and handling costs and mechanical injury to apples among operators; and the lack of any relationship between packing costs and mechanical injury. This suggests that there is an opportunity for most operators to reduce both costs and mechanical injury. If all operators



PICTURE 8—Bagging Machine.

could become as efficient as the lowest-cost operators, the costs of packing and handling apples in the Appalachian Area would be reduced considerably. No doubt, even the present low-cost operators could further improve their methods. This would mean even more savings in packing and handling costs.

On the average, the total packing cost for the tray pack was $0.91, for the bushel basket, $0.86, and $1.01 for the Northwest box. Since packing costs are not involved in sales to the processor, apple growers, on the average, would have to receive from $0.86 to $1.04 more per packed bushel sold to the fresh market than an unpacked bushel sold to the processor market in order to receive the same net from the two outlets. The lowest-cost packer would have to receive only $0.79 per bushel more from the fresh than from the processor market to receive the same net; whereas the highest-cost packer would have to receive $1.11 more from the fresh. This is on the assumption that apple quality, and marketing costs, other than packing, are the same, regardless of market outlet used. To the extent that there are differences, these differences would have to be taken into consideration.

Except for costs of road truck and driver, handling costs for moving one hundred crates of apples from under the tree to the packing house ranged from a low of $0.69 to a high of $2.53. Handling costs for loading out one hundred pack containers ranged, among packers, from a low of $0.47 to a high of $0.83.

In general, no machine tested could be condemned because of excess fruit bruising. However, most of them could be improved through better engineering and designing. Although consumers tolerate a reasonable amount of bruising on apples, it is probable that they will be less tolerant in the future. Continued engineering research to improve present machines is essential, and eventually new principles for sizing, sorting, and packaging will be needed. The fresh-fruit packaging plants operating with larger volumes, as indicated by present trends, will be employing new machines in the future, using electronic, pneumatic and hydraulic devices which are not even on the designing boards at present.

The amount of mechanical damage which occurs in today's packing houses varies more with management and supervision than it does with the particular type of machinery. These factors of management deal with machinery adjustments, personnel training, and a smooth but flexible design and layout.

The findings of this report offer encouragement for reducing packing and handling costs and mechanical injury in the Appalachian apple industry. From the time and motion and work sampling data to be presented in another report, an attempt will be made to synthesize a low-cost packing and handling method. If possible, the synthesized method will be field tested for operating costs and mechanical injury to apples.